ENVIRONMENTAL ASSESSMENT (LCA) AS GUIDE PARAMETER IN CHOOSING ECO-EFFICIENT MATERIALS

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Summary

Sustainable design can be pursued only through the use of **ecological materials** which are environmentally compatible. For this reason, it is necessary to carry out a **control during the whole** "**life cycle**" of building materials and components to determine their ecological sustainability.

The aim of the present research is to show the **environmental impact assessment** of different **solutions of vertical building envelope**, realised using **eco-efficient materials**, in particular following "low-tech" solutions deriving/ derived from renewable resources, by means of the recovery of local material culture.

Life Cycle Assessment (UNI EN ISO 14040), also called **LCA**, is the methodology adopted in this research; it is a helpful system used also in building construction to evaluate and quantify environmental impact of building manufactures, by studying them at different levels (from materials, products and building system, till the entire edifice). It is paid attention to every single **material** and to the **building process**, by evaluating their environmental impact during the different life cycle stages: from *raw materials supply to production, building and managing stages, from maintenance to final disposal of materials at their end-of-life stage*. Transports, energy consumption, emissions into air, water and soil of polluting substances are also taken into account. Each life-cycle stage is assessed as regards <u>human health</u>, <u>ecosystem quality</u> and possible <u>depletion</u> <u>of resources</u> taken from planet Earth.

Keywords: sustainability, local resources, eco-efficient materials, life cycle assessment, environmental impact

1 Introduction

The aim of technical innovation in building construction has always been that of improving the performance of the final products, that is their efficiency in satisfying the user's needs. Today the attention is focused on performances which were not even considered some years ago: reduction of pollution, use of naturally reproducible resources, reduction of energy consumption in each phase of the building process, reuse and recycling of materials. These performances integrate and do not replace those normally required by the final products (Antonini, Landriscina, 2007).

The environmental emergency with which we are living today has made the sustainability of processes and products the core of technological innovation development.

It is difficult to set the parameters on which a material, product or building solution can be considered better than others from an energy respect and environmental point of view. **Life cycle assessment** and the **study of its interactions with the environment during each phase of the building process** is one of the means used to achieve this purpose.

It is common knowledge that the building industry consumes non-renewable resources and produces significant environmental impacts. Huge quantities of mining resources (types of natural stone, gravel, sand, clay) are employed in the production of building materials and products, and significant quantities of energy resources are consumed every year as a consequence of the functioning of buildings. Within this context the introduction and use of materials, components and building solutions deriving from **renewable resources** has become extremely necessary in order to allow a reduction of the environmental impact, to reduce CO_2 emissions and to obtain a decrease of primary energy consumption during the production process of building materials.

2 Research objective

The objective of the present research is to promote an effective alternative to the current building production model. The survey aims at proposing materials, products and building solutions with reduced environmental impact and low energy consumption during the material supply and production phases, as well as during the installation, maintenance and end-of-life phases, for a full recyclability of the materials employed.

This approach will be established on "**low tech**" **solutions**, that is on **systems based on the use of local renewable resources (earth, straw, recyclable stone)**.

The LCA will provide the **sustainability assessment of these solutions during their production, installation, use and disposal processes**.

Fig. 1 Renewable resources (earth, straw, recyclable stone) employed to achieve the building solutions proposed in the survey

3 Methodology

The methodology employed to carry out this research is the *Life Cycle Assessment*, also known as **LCA** (ISO 14040, 2006), recognized by the international science community and governed by the UNI EN ISO 14040 procedures (ISO 14040, 2006; ISO 14044, 2006).

The software used to insert LCI (ISO 14044, 2006) inventory data is called **SimaPro 7** (Pré, 2006).

The method employed for the environmental damage assessment is called **Eco-Indicator 99**; it is a methodology developed by Pré (Pré, 2001) which allows to collect LCA results into units or numbers called Eco-indicators (Pt). This method assesses only three types of environmental damages - **Human Health**, **Ecosystem Quality**, **Resources** - and each of them includes a certain number of "impact categories".

In all, there are 11 categories: Carcinogens, Respiratory Organics, Respiratory Inorganics, Climate Change, Radiation, Ozone Layer on **Human Health** impact category; Ecotoxicity, Acidification/Eutrophication, Land Use on **Ecosystem Quality** impact category; Fossil Fuels, Minerals on **Resources** impact category (De Santoli, 2006).

4 Environmental performances of the study cases

4.1 Study cases and system boundaries

The environmental analysis concerns the following study cases and is applied to 1sq m of vertical wall:

- *vertical wall realised with modular system of granulated material in metal gabions;*
- *vertical wall realised with modular system in wood and straw;*
- *vertical wall realised with hand-made adobe bricks technique;*
- *vertical wall realised with straw earth technique.*

For each of the study cases analysed, all the **phases of the building process** were considered, as well as their respective measurable environmental impacts:

- *Raw materials extraction and transport*
- *Pre-processing*
- *Production*
- *Distribution*
- *Installation*
- *Use*
- *Maintenance*
- *Recycling and disposal*

4.2 Results

The LCA applied to "low tech" solutions deriving from renewable resources shows how they represent building systems with low environmental impact. Figure 2 illustrates the result of the comparative analysis and shows the eco-points of the environmental performances analysed.

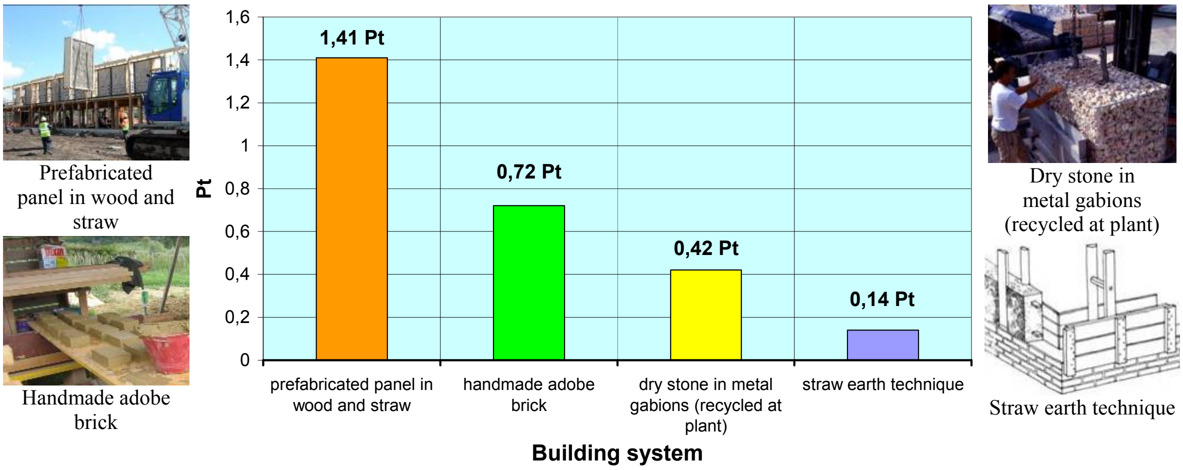

Fig. 2 Comparison of building solutions. Comparative damage assessment with the Eco-Indicator 99 method

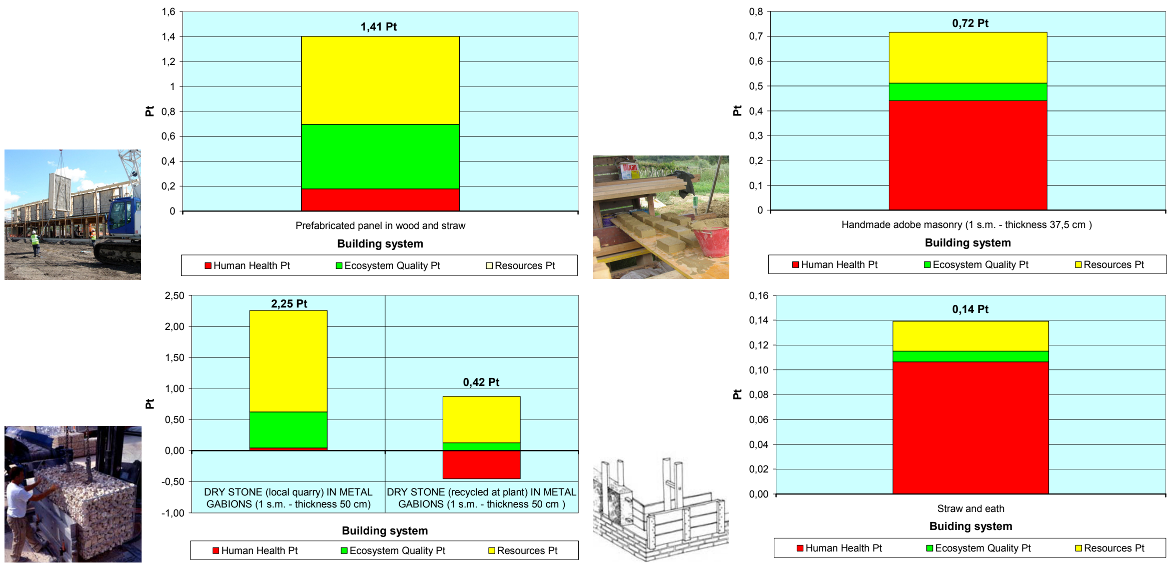

Fig. 3 Assessment based on damage categories of the building solutions analysed, with the Eco-indicator 99 method

Figure 3 illustrates the assessment results for damage categories:

- **vertical wall realised with modular system in wood and straw:**
the assessment reveals a 1.41 Pt impact. The damage indicator "**resources**" shows an impact percentage value (50.3%) higher than the other two values assessed by the method, due to the activities concerned with the supply of materials and semi-finished products;

- **vertical wall realised with hand-made adobe bricks technique:**
the assessment reveals a 0.72 Pt overall impact with a strong incidence in the "**human health**" damage category, due to the emissions released during the masonry demolition

(52.23%) and the transport of materials (43.99%) such as sand and straw from the supply to the production location;

- **vertical wall realised with modular system of granulated material in metal gabions:**

The assessment reveals a 0.42 Pt impact mostly concerning the "**resources**" damage category, mainly due to the electric energy consumption during the metal gabion welding process;

- **vertical wall realised with straw earth technique:**

the assessment reveals a 0.14 Pt impact mainly concerning the "**human health**" damage category (76.4%), due to the emissions released by the machinery employed during the wall demolition and by the means used to transport the straw from the supply location (local farm) to the building site.

Figure 4 compares the eco-efficient solutions (circled in red) with the standard system of the wall portion, that in the stratigraphy shows: internal two-coat plaster, hollow clay blocks porizzato, steam barrier, thermal insulation layer, expanded polystyrene panel, air space and face bricks (circled in blue). Technical performances being equal, the damage reduction for the study cases is considerably lower.

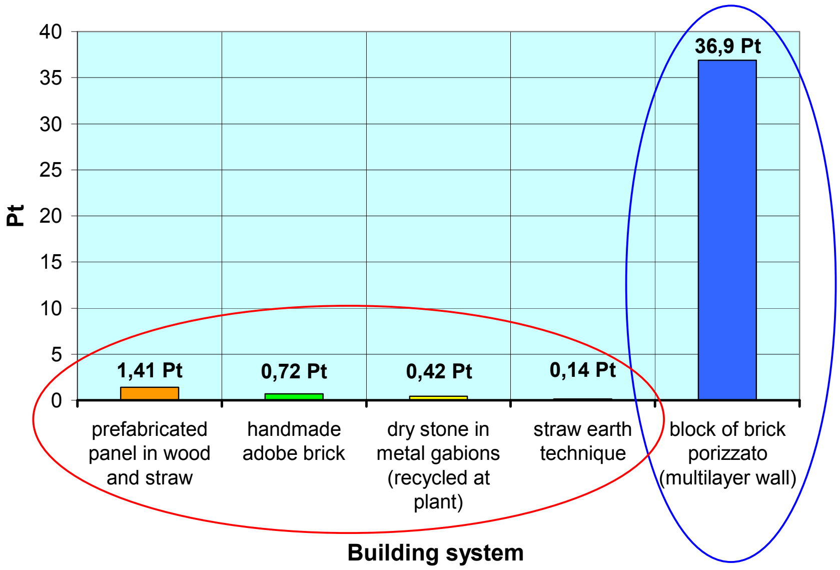

Fig. 4 Local building solutions compared to standard systems. Comparative damage assessment with the Eco Indicator 99 method

5 Conclusions

The approach to an "**ecological**" building construction and the choice of materials and technological systems that, due to their "local" feature, require small energy in order to be produced, transported, managed and disposed at the end of their life (since easily recyclable or reusable) provide more sustainable solutions and define the **references for eco-compatible design choices** within their life cycle. In addition, the management and exploitation of **local resources** provide **positive consequences** not only from an environmental but also from an economical and social point of view. For instance we can mention:

- **a reduction of transport emissions;**
- **a reduction of resources import and export costs;**
- **a proper management of local natural resources;**
- **a greater awareness of both resources used and impacts generated.**

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